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THE LATE OLIVER HEAVISIDE, F.R.S.

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Oliver Heaviside

By F. GILL

ALTHOUGH abler pens[1] have expressed appreciation of the late Oliver Heaviside, it is perhaps permissible for an English telephone engineer to present a note regarding him. Of his life-history not very much is known; but he may have been influenced in his choice of a career by the fact that he was a nephew of the famous telegraph engineer Sir Charles Wheatstone. Heaviside was born in London on May 13, 1850; he entered the service of the GreatNorthern Telegraph Company, operating submarine cables, and he remained in that service, at Newcastle-on-Tyne, until 1874. While he was with the Telegraph Company, he published in 1873 a paper showing the possibility of quadruplex telegraphy.

At the age of about 24, owing, it is suggested, to increasing deafness, he left the service of that Company and took up mathematical research work. How he acquired his mathematical training does not seem to be known;[2] perhaps he was self-taught,—in some of his Papers he implies it. By whatever means he mastered the principles, it is evident that he was an ardent student of Maxwell, for constantly in Heaviside's own writing runs a vein of appreciation of Maxwell. For some time he lived in London, then he moved to Paignton in Devonshire; his Electrical Papers are written from there, and he died at the neighboring town of Torquay on February 4, 1925, in his 75th year.

That is about all the personal history at present available, and yet it gives a clue to a dominant note in his character, viz., reluctance to come into prominence, originating, perhaps, in a kind of shyness, which ultimately led to the recluse state. It is strange that so remarkable an investigator should, in his earlier manhood, have convinced so few, notwithstanding the fact that his voluminous writings made his name well known. It must, however, be remembered that his articles were very difficult, even for advanced mathematicians to follow, for he used a system of mathematics which, at that time

[1] *The Electrician*, Vol. XCIV, p. 174, by Sir Oliver Lodge, F.R.S., O.M. *Nature*, Vol. 115, p. 237, by Dr. Alex. Russell, F.R.S.

[2] Was he the youth with the frown in the library? He says he "then died," but also says "he was eaten up by lions." (E.M.T., Vol. III, pp. 1 and 135.)

was unusual. Whatever the cause, the fact remains that until about the year 1900 few engineers understood him.

Coming to his work, what was it that Heaviside did, and upon what does his fame rest? That is too large a subject for a telephone engineer to answer fully, but as regards communication engineering something may be said. His great achievement was the discovery of the laws governing the propagation of energy in circuits. He recognized the relationship between frequency and distortion; he illustrated it by numerical examples, and he showed what was required to make a "distortionless circuit." Further, he showed the effects of "attenuation" and the result of "inductance" (these words were his own coinage) in improving telephony. He also explained how the inductance of circuits could be increased; he suggested the use of continuous loading, of lumped inductance in the form of coils, and he pointed out the difficulty of obtaining sufficiently low resistance in such coils. He investigated the effect of sea and land and the upper atmosphere on the propagation of radio energy and how it was that this energy could be transmitted over the mountain of earth intervening between two distant places.

His activity in these matters can best be illustrated by extracts from his writings, as follows:

In his "Electrical Papers," Vol. II, written in 1887, p. 164, he gives numerical examples of frequency distortion and of its correction, and says:

> "It is the very essence of good long distance telephony that inductance should *not* be negligible."

In his "Electromagnetic Theory," Vol. I, published in 1893, he considers in Section 218, p. 441.

> "various ways, good and bad, of increasing the inductance of circuits"

He suggests, page 445, the use of

> ". . . inductance in isolated lumps. This means the insertion of inductance coils at intervals in the main circuit. That is to say just as the effect of uniform leakage may be imitated by leakage concentrated at distinct points, so we should try to imitate the inertial effects of uniform inductance by concentrating the inductance at distinct points. The more points the better, of course . . . The Electrical difficulty here is that inductance coils have resistance as well, and if this is too great the remedy is worse than the disease.

. . . To get large inductance with small resistance, or, more generally, to make coils having large time constants, requires the use of plenty of copper to get the conductance, and plenty of iron to get the inductance, employing a properly closed magnetic circuit properly divided to prevent extra resistance and cancellation of the increased inductance . . . This plan . . . is a straightforward way of increasing the L largely without too much increasing the resistance and may be worth working out and development. But I should add that there is, so far, no direct evidence of the beneficial action of inductance brought about in this way."

In "Electrical Papers," Vol. II, p. 311, he deals with reflected waves, and on page 347 he says:

" . . . but the transmitter and the receiving telephone distort the proper signals themselves. The distortion due to the electrical part of the receiver may, however, be minimized by a suitable choice of its impedance.

"Electromagnetic Theory," Vol. I, p. 404:—

"We have seen that there are four distinct quantities which fundamentally control the propagation of 'signals' or disturbances along a circuit, symbolized by R, K, L, and S, the resistance, external conductance, inductance, and permittance;"

"Electromagnetic Theory," Vol. I, p. 411:—

"It is not merely enough that signals should arrive without being distorted too much; but they must also be big enough to be useful . . . Nor can we fix any limiting distance by consideration of distortion alone. And even if we could magnify very weak currents, say a thousandfold, at the receiving end, we should simultaneously magnify the foreign interferences. In a normal state of things interferences should be only a small fraction of the principal or working current. But if the latter be too much attenuated, the interferences become relatively important, and a source of very serious distortion. We are, therefore, led to examine the influence of the different circuit constants on the attenuation, as compared with their influence on the distortion."

"Electrical Papers," Vol. II, p. 402:—

"I was led to it (the distortionless circuits), by an examination of the effect of telephones bridged across a common circuit (the proper place for intermediate apparatus, removing their impedance) on waves transmitted along the circuit."

With regard to Radio Communication, one extract must suffice writing on The Electric Telegraph in June, 1902, for the Encyclopedia Britannica, he says,—"Electromagnetic Theory," Vol. III, p. 335:—

"There is something similar in 'wireless' telegraphy. Sea water, though transparent to light, has quite enough conductivity to make it behave as a conductor for Hertzian waves, and the same is true in a more imperfect manner of the earth. Hence the waves accommodate themselves to the surface of the sea in the same way as waves follow wires. The irregularities make confusion, no doubt, but the main waves are pulled round by the curvature of the earth, and do not jump off. There is another consideration. There may possibly be a sufficiently conducting layer in the upper air. If so, the waves will, so to speak, catch on to it more or less. Then the guidance will be by the sea on one side and the upper layer on the other. But obstructions, on land especially, may not be conducting enough to make waves go round them fairly. The waves will go partly through them."

Probably due to his long seclusion, his approach to certain subjects was rather critical. At one time I tried to get a portrait of him for the Institution of Electrical Engineers, but failed;—he did not wish to have his photograph exhibited, he thought that "one of the worst results (of such exhibition) was that it makes the public characters think they really are very important people, and that it is therefore a principle of their lives to stand upon doorsteps to be photographed."

On another occasion when I sent him a copy of an article by a distinguished telephone engineer on "The Heaviside Operational Calculus," he replied that he had "looked through the paper . . . with much interest, to see what progress is being made with the academical lot, whom I have usually found to be very stubborn and sometimes wilfully blind."

Some have held that Heaviside was not recognized as he ought to have been. This was probably the case some time ago, but not in recent years. The same is true of many very great men who were much in advance of their time, for the English have the national characteristic that they do not make much fuss about their great men. So if Heaviside suffered, he shared this experience in common with other pioneers who deserved higher recognition. See, for example, what Heaviside himself said about one of these, in a footnote in "Electromagnetic Theory," Vol. III, p. 89:

"George Francis Fitzgerald is dead. The premature loss of a man of such striking original genius and such wide sympathies

will be considered by those who knew him and his work to be a national misfortune. Of course, the 'nation' knows nothing about it, or why it should be so."

During the last 20 years or more, the significance and luminous quality of the work of Heaviside has been increasing by acknowledged mathematicians and by practical telephone, telegraph and radio engineers. To other electrical engineers his treatment of wave-transmission has not yet appealed quite so strongly.

Probably his first recognition came from his contribution to the problem—"Electromagnetic Induction and its Propagation" in the *Electrician*. It appeared as a series of articles between January, 1885 and December, 1887. His "Electrical Papers" were written at various times and were published in two volumes in 1892. Then followed his three volumes on "Electromagnetic Theory"—on the basis of the *Electrician* articles—published in 1893, 1899 and 1912. He also wrote, in 1902, the article on the "Theory of the Electric Telegraph" in the "Encyclopedia Britannica."

In 1891, the Royal Society made him a Fellow. In 1899, the American Academy of Arts and Sciences elected him an Honorary Member. In 1908 the Institution of Electrical Engineers did the same, followed by the American Institute of Electrical Engineers in 1917. The Literary and Philosophical Society of Manchester also elected him an Honorary Member. He was an Hon. Ph.D. of the University of Gottingen, and in 1921, the Institution of Electrical Engineers conferred upon him the highest award in their gift—the Faraday Medal. He was the first recipient of this Medal which was established to commemorate the 50th anniversary of the founding of the original Society of Telegraph Engineers and of Electricians, and since then the medal has been bestowed upon Sir Charles Parsons, Dr. S. Z. de Ferranti, and Sir J. J. Thomson.

From time to time there were reports of his living in great poverty, and attempts were made to help him. These reports lacked proportion, but it is true he had not much money and perhaps still less comfort; he was a difficult man to help. Towards the end of his life he received from the British Government a Civil Pension. His independent character rendered it necessary that offers of assistance should be tactfully made and apparently this was not always the case, as I believe help was sometimes refused; but there were those who succeeded. Another difficulty was his unconventional mode of living which caused him, in his last years, to live as a recluse, cooking and looking after his house alone.

Just what other work Heaviside did, in addition to his published writings, is not at present known to me. I believe he left a good deal of manuscript, but whether it is in such a state that it could be completed by another, I do not know. Let me conclude this note by an extract from his last chapter of his last book, "Electromagnetic Theory," Vol. III, page 519:—

> "As the universe is boundless one way, towards the great, so it is equally boundless the other way, towards the small; and important events may arise from what is going on in the inside of atoms, and again, in the inside of electrons. There is no energetic difficulty. Large amounts of energy may be very condensed by reason of great forces at small distances. How electrons are made has not yet been discovered. From the atom to the electron is a great step, but is not finality.
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> "Living matter is sometimes, perhaps generally, left out of consideration when asserting the well-known proposition that the course of events in the physical world is determined by its present state, and by the laws followed. But I do not see how living matter can be fairly left out. For we do not know where life begins, if it has a beginning. There may be and probably is no ultimate distinction between the living and the dead."